



Application No. 10/544,234

## Attachment A

Partial translation of JP 2002-26070 A1

## VERIFICATION OF TRANSLATION

I, Shoichi Hirose, hereby declare that:

I am conversant with the English and Japanese languages and particularly with English and Japanese documents pertaining to patents and have over 25 years of experience in translating Japanese patent documents into English;

I have reviewed JP 2002-26070 A1 and the attached English translation of selected portions thereof; and

the attached English translation is an accurate and complete translation of the selected portions of JP 2002-26070 A1.

  
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13th of November 2007  
Date

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## Partial translation of JP 2002-26070 A1 (Segawa)

[Claims]

[Claim 1]

A semiconductor apparatus in which electrodes of a wiring board are connected to the electrodes of an IC chip by an anisotropic electrically conductive material,

characterized in that the anisotropic electrically conductive material has meltable electrically conductive particles having a melting point higher than the curing reaction temperature of an insulating resin dispersed in the insulating resin.

[Claim 2]

A method of manufacturing a semiconductor device in which the electrodes of a wiring board and the electrodes of an IC chip are secured to each other by a sealing resin and electrically connected to each other,

characterized by a connecting step in which the electrodes of the wiring board and the electrodes of the IC chip are electrically connected by melting meltable electrically conducting particles which are dispersed in a sealing resin at a temperature at which the sealing resin does not cure, and a curing step of curing the sealing resin at a temperature at which the meltable electrically conductive particles do not melt after connecting the electrodes of the wiring board and the electrodes of the IC chip.

[Claim 3]

A method of manufacturing a semiconductor device as set forth in claim 2 characterized by having a step of carrying out inspection of electrical conduction between electrodes of the IC chip and electrodes of the wiring board after the connection step and before the curing step.

[Detailed Explanation of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a semiconductor device having a bare chip IC mounted on a wiring board and a method for its manufacture.

[0002]

[Prior Art]

The development of bare chip mounting technology for mounting a silicon bare chip IC directly on a wiring board is progressing primarily as applied to the manufacture of portable telephones, personal computers, and the like. In particular, flip chip mounting technology in which the connecting electrodes of a bare chip IC are made to oppose a wiring board and face-down bonding is performed is being increasingly put to use because it is superior for high density mounting.

[0003] - [0019]

omitted - discussion of prior art methods

[0020] - [0023]

omitted - discussion of problems of prior art methods

[0024]

The present invention was made in light of these circumstances, and its object is to provide a method of manufacturing a semiconductor device having a bare chip IC mounted on a wiring board with high productivity using a simple process and a semiconductor device resulting from the method.

[0025] - [0027]

omitted: summary of the claims

[0028]

[Embodiments of the Invention]

Below, embodiments of a semiconductor device according to this invention and a method for its manufacture will be explained while referring to the drawings.

[0029]

Figure 1 is a side cross-sectional view of a semiconductor device showing a first embodiment of this invention. A wiring board 1 has a copper wiring pattern with a pitch of 300  $\mu\text{m}$  formed on the surface of a glass epoxy substrate with a thickness of around 1.0 mm. Electrodes 2a, 2b, 2c ... 2n having gold plating or solder plating are formed on a portion thereof. In addition to a glass epoxy material, a polyimide, a ceramic, or the like

can be used as the material of the board.

[0030]

A bare chip IC 4 which is an IC chip is mounted on these electrodes 2a, 2b, 2c ... 2n through solder bumps 3a and 3b. The surface of the bare chip IC 4 has the solder bumps 3a, 3b formed atop connecting electrodes 4a, 4b, 4c ... 4n by an electroplating method.

[0031]

An anisotropic electrically conductive material 7 which comprises an insulating resin 5 which is a sealing resin such as an epoxy resin having meltable electrically conductive particles 6a, 6b, 6c ... 6n dispersed therein fills the space between the wiring board 1 and the bare chip IC 4 as well as the side surface of the bare chip IC 4.

[0032]

The meltable electrically conductive particles 6a, 6b, 6c ... 6n can be any of those shown in Figures 2(a) and 2(b) used alone or as an arbitrary combination thereof.

[0033]

The meltable electrically conductive particles 6a, 6b, 6c ... 6n shown in Figure 2(a) are formed by coating treatment using a film of a flux 9 with a thickness of around 10 - 20  $\mu\text{m}$  on the exterior of a solder ball 8 having a particle diameter of around

30 - 50  $\mu\text{m}$ . Although not shown, a structure may be employed in which the structure of the solder ball and the flux is reversed and the center of a meltable electrically conductive particle is made a core in the form of a ball of flux having a particle diameter of around 20 - 35  $\mu\text{m}$ , and the outside thereof is covered with solder ..... (description of method of manufacturing the particles - omitted)

[0034]

The meltable electrically conductive particles 6a, 6b, 6c ... 6n shown in Figure 2(b) have a metal core 11 of copper or the like with an exterior coated with a bonding material in the form of solder 12, and the outside thereof is further coated with flux 9.

[0035]

The meltable electrically conductive particles 6a, 6b, 6c ... 6n shown in Figure 2(c) are constituted such that the meltable electrically conductive particles 6a, 6b, 6c ... 6n having the structure shown in Figure 2(b) are not coated with a flux 9 as an outermost layer. In this case, when they are dispersed in an anisotropic electrically conductive material 7, either a flux is separately dispersed or the insulting resin 5 is given a fluxing action.

[0036]

omitted - description of chemical composition of the

meltable electrically conductive particles

[0037]

The anisotropic electrically conductive material is manufactured by dispersing approximately 10 - 25% of any of the above-described meltable electrically conductive particles in an insulating thermosetting resin. The anisotropic electrically conductive material may be in the form of a sheet, or it may be formed as a paste. A method of manufacturing an anisotropic electrically conductive material 7 in the form of a sheet comprises previously dispersing meltable electrically conductive particles in an epoxy resin prior to curing and performing kneading, stretching the kneaded mixture into the form of a sheet, and then temporarily curing it. An acrylic (modified) resin, a polyimide resin, a butadiene resin, a phenolic resin, or the like can be used as the insulating thermosetting resin.

[0038]

Next, a method of mounting a flip chip using an anisotropic electrically conductive material according to a first embodiment of this invention will be explained. Figures 3(a) - 3(e) are schematic process views showing a flip chip mounting method of this invention. A typically used apparatus is employed as a bonding apparatus, so an explanation of this apparatus will be omitted.

[0039]

First, a wiring board 1 having a copper wiring pattern with a pitch of 300  $\mu\text{m}$  formed on the surface of a glass epoxy material with a thickness of around 1.0 mm and having electrodes 2a, 2b, 2c ... 2n having gold plating or solder treatment formed on a portion thereof is set in an unillustrated bonding apparatus (Figure 3(a)).

[0040]

Next, an anisotropic electrically conductive material 7 in the form of a sheet cut to the shape of the electrodes 2a, 2b, 2c ... 2n of the wiring board 1 or cut to the shape of the outer size of the chip is formed atop the wiring board 1.

[0041]

Alternatively, instead of an anisotropic electrically conductive material 7 in the form of a sheet, an anisotropic electrically conductive paste 7a is applied to the surface of the wiring board 1 by a dispenser 13 (Figure 3(b)).

[0042]

Next, a bare chip IC 4 having solder bumps 3a, 3b previously formed atop connecting electrodes 4a, 4b, 4c ... 4n is sucked by a bonding tool 14, the solder bumps 3a, 3b are aligned with the electrodes 2a, 2b, 2c . . . 2n of the wiring board 1 through the anisotropic electrically conductive material 7 (or the anisotropic electrically conductive paste 7a), and the bare chip IC 4 is temporarily secured in place (Figure 3(c)). At this

time, the bare chip IC 4 and the wiring board 1 can be secured to each other by the adhesion of the insulating resin 5, which is an epoxy resin, of the anisotropic electrically conductive material 7. A plurality of the meltable electrically conductive particles 6a, 6b, 6c ... 6n of the anisotropic electrically conductive material 7 are dispersed between the solder bumps 3a, 3b of the bare chip IC 4 and the electrodes 2a, 2b, 2c ... 2n of the wiring board 1.

[0043]

Next, using a bonding tool 14 which has a heating function, heat and pressure are applied with a peak temperature during heating of approximately 150° C to bond the electrodes 2a, 2b, 2c ... 2n of the wiring board 1 and the solder bumps 3a and 3b, and the bare chip IC 4 is electrically connected to the wiring board 1. At the time of this bonding, the flux 9 in the meltable electrically conductive particles 6a, 6b, 6c ... 6n of the anisotropic electrically conductive material 7 promotes the wettability of solder, and good soldering can be achieved (Figure 3(d)).

[0044]

Next, the insulating resin 5, which is an epoxy resin, of the anisotropic electrically conductive material 7 is thermally set at from around 150° to around 200° C. As a result of this treatment, connection of fine soldered portions and resin sealing by the insulating resin 5 are realized in a single reflow step

(Figure 3(e)).

[0045]

Figure 4 is a chart showing a temperature profile for use in explaining the sequence of a flip chip mounting process of this invention.

[0046]

In this mounting process, the solder has a melting temperature which is lower than the curing temperature of the insulating resin. In the first half of the process, solder connection (temperature T2) is carried out, and in the latter half of the process, resin curing (temperature T1) is carried out.

[0047]

The timing of curing of the insulating resin can be controlled by the composition of the insulating resin and the curing agent. Therefore, the composition of the resin is controlled so that the curing rate of the insulating resin is 0% at the time of solder connection (at temperature T2) and becomes 100% at the time of curing of the resin (at temperature T1). For example, the curing temperature can be adjusted to be in the range of 120 to 200° C and above by using a specific modified epoxy resin together with a curing agent (amine or the like).

[0048]

The curing time can be adjusted to be from several seconds to several hours. In order to realize curing in a short length of time, it is effective to form the curing agent into microcapsules. In particular, in the case of a curing time of several seconds, the timing of the curing reaction can be controlled by using microcapsules having a curing agent coated with a thin resin film which tears at a prescribed temperature (such as at several tens of degrees C).

[0049]

In this case, the temperature profile can be easily controlled by installing a heater in the stage of the bonding tool of the bonding apparatus.

[0050]

This method has the merit that the bare chip IC 4 is pressed at the time of solder bonding and electrical connection can be realized with certainty. In addition, in a subsequent inspection step, when defective parts are discovered, the joints can be melted by heating, the bare chip IC can be separated from the wiring board, the defective parts can be exchanged, and bonding can be performed by the above process to manufacture a good part.

[0051]

In this first embodiment, as an added step after solder bonding, inspection of connections of the bare chip IC can be carried out, and when defective parts are discovered, the joints

can be melted by heating, and repair of connections or the like can be carried out.

[0052]

This is because, as shown in Figure 4, even if solder connection is carried out, the insulating resin is not cured, so when bad connections or defective operation of an IC chip is ascertained, the bare chip IC can easily be removed from the wiring board by heating and melting the solder connections. As a result, a different bare chip IC can be remounted (repair can be performed).

[0053]

Figure 5 shows a temperature profile for a process in which an inspection step is added. In this case, electrical inspection of connections is carried out after solder connection. For this purpose, a wiring board having a bare chip IC mounted thereon is once removed from the bonding apparatus. Then, if necessary, a step such as repair is carried out, and then oven drying or the like is carried out to cure the resin.

[0054]

At the time of oven drying, in order to avoid the case in which the solder connection opens due to expansion due to heating of the insulating resin, pressing is preferably carried out from the rear surface of the bare chip IC using a pressing means (not shown).

[0055]

Next, a second embodiment of the present invention will be explained.

[0056]

Figure 6 is a side cross-sectional view of a semiconductor device which is a second embodiment showing an example of a semiconductor device of this invention.

[0057]

A wiring board 21 has a copper wiring pattern with a pitch of 300  $\mu\text{m}$  formed on the surface of a glass epoxy substrate with a thickness of approximately 1.0 mm, and electrodes 22a, 22b, 22c ... 22n having gold plating or solder treatment are formed on a portion thereof. In addition to a glass epoxy material, the material of the board may be a polyimide, a ceramic, or the like.

[0058]

A bare chip IC 24 is mounted by being connected atop the electrodes 22a, 22b, 22c ... 22n by connecting electrodes 24a, 24b, 24c ... 24n. An anisotropic electrically conductive material 27 having meltable electrically conductive particles 26a, 26b, 26c ... 26n dispersed in an insulating resin 25 such as an epoxy resin fills the space between the wiring board 21 and the bare chip IC 24 and the side surface of the bare chip IC 24.

[0059]

The meltable electrically conductive particles 26a, 26b, 26c ... 26n and the anisotropic electrically conductive material 27 are the same as explained with respect to the first embodiment, so an explanation thereof is omitted.

[0060]

Next, a mounting method of the second embodiment of this invention will be explained while referring to schematic process diagrams shown in Figures 7(a) to 7(e).

[0061]

In the same manner as in the first embodiment, the bonding apparatus is a typically used apparatus, so an explanation concerning this apparatus will be omitted.

[0062]

First, a wiring board 1 having a copper electrode pattern with a pitch of 300  $\mu\text{m}$  formed on the surface of a glass epoxy substrate with a thickness of approximately 1.0 mm and having electrodes 22a, 22b, 22c ... 22n subjected to gold plating or solder treatment formed on a portion thereof is set in an unillustrated bonding apparatus (Figure 7(a)).

[0063]

Next, a sheet of an anisotropic electrically conductive material 27a having the shape of the electrodes 22a, 22b, 22c ... 22n of the wiring board 21 or cut to the outer shape of the outer

size of the chip is formed atop the wiring board 21. Instead of an anisotropic electrically conductive material 27 in the form of a sheet, an anisotropic electrically conductive paste 27a may be coated on the surface of the wiring board 21 using a dispenser 33 (Figure 7(b)).

[0064]

Next, a bare chip IC 24 which is sucked by a bonding tool 34 and which has connecting electrodes 24a, 24b, 24c ... 24n previously formed thereon is aligned with electrodes 22a, 22b, 22c ... 22n of the wiring board 21 through the anisotropic electrically conductive material 27 (or the anisotropic electrically conductive paste 27a) having meltable electrically conductive particles 26a, 26b, 26c ... 26n dispersed therein and is temporarily secured in place (Figure 7(c)). At this time, the bare chip IC 24 and the wiring board 21 can be secured to each other by the adhesive force of the insulating resin 25, which is an epoxy resin, of the anisotropic electrically conductive material 27. A plurality of the meltable electrically conductive particles 26a, 26b, 26c ... 26n of the anisotropic electrically conductive material 27 are dispersed between the connecting electrodes 24a, 24b, 24c ... 24n of the bare chip IC 24 and the electrodes 22a, 22b, 22c ... 22n of the wiring board 21.

[0065]

The connecting electrodes 24a, 24b, 24c ... 24n of the bare chip IC 24 may use a barrier metal formed by vapor deposition or

sputtering of a metal such as chromium, nickel, or gold, or they may use a combination of electroless nickel plating and gold plating. In the same manner as in the first embodiment, one having solder bumps 3a, 3b formed thereon may be used. In either case, surface treatment may be performed on the connecting electrodes 24a, 24b, 24c ... 24n so that they are wet when the meltable electrically conductive particles melt.

[0066]

Next, using a bonding tool having a heating function, the solder is melted by heating with a peak temperature of around 240° C, and the electrodes 22a, 22b, 22c ... 22n of the wiring board 21 are electrically connected to the connecting electrodes 24a, 24b, 24c ... 24n of the bare chip IC 24. At the time of this connection, the flux 29 in the meltable electrically conductive particles of the anisotropic electrically conductive material 27 promotes the wettability of solder, and good soldering can be achieved (Figure 7(d)).

[0067]

In addition, the insulating resin 25, which is an epoxy resin, of the anisotropic electrically conductive material 27 is heated to approximately 150 to 200° C and cured. As a result of this treatment, a manufacturing process in which connection of fine solder and resin sealing are continuously carried out can be realized.

[0068]

Figure 8 is a chart showing the temperature profile for explaining the sequence in this mounting process.

[0069]

In this mounting process, the solder which is used has a melting temperature which is higher than the curing temperature of the insulating resin. In the first half of the process, solder connection (T2) is carried out, and in the last half of the process, resin curing (T1) is carried out.

[0070]

As explained with respect to the first embodiment, the timing of hardening of the insulating resin can be controlled by the combination of the composition of the insulating resin and the curing agent, so by slowing down the hardening reaction of the insulating resin at the time of connection by soldering, control can be carried out so as to maintain the insulating resin in an uncured state.

[0071]

As the meltable electrically conductive particles dispersed in the anisotropic electrically conductive materials or the anisotropic electrically conductive paste, in addition to the forms shown in Figures 2(a) - (c), depending upon the temperature of use, the solder balls 8 and the flux 9 can be separated and can be used in a form in which they are dispersed in a resin.

[0072]

As described above, according to the present invention, flux application and a washing step which were carried out in a usual conventional manufacturing process become unnecessary, and the process of sealing a resin becomes extremely simple, so simplification of a manufacturing process can be realized.

[0073]

In addition, when defective parts develop after mounting of a bare chip IC on a wiring board, a step of peeling it off (repairing it) can be added, so losses during the manufacturing process can be reduced.

[0074]

[Effects of the Invention]

According to the present invention, a simple manufacturing process is used, so a semiconductor device having good connections between the electrodes of a wiring board and a bare chip IC and a method for its manufacture can be provided.

[Brief Explanation of the Drawings]

Figure 1 - A side cross-sectional view of a semiconductor device which is a first embodiment showing an example of this invention.

Figures 2(a) - (c) are structural views of meltable electrically conductive particles of this invention.

Figure 3(a) - (e) are schematic process views of a mounting method of a first embodiment of this invention.

Figure 4 - A chart of the temperature profile of an embodiment of a mounting method of this invention.

Figure 5 - A chart of the temperature profile of a process to which an inspection step is added.

Figure 6 - A side cross-sectional view of a semiconductor device which is a second embodiment showing an example of this invention.

Figures 7(a) - (e) are schematic process views of a mounting method of a second embodiment of this invention.

Figure 8 - A chart showing a temperature profile in a second embodiment of this invention.

Figures 9(a) - (f) are schematic process diagrams of a conventional mounting method.

Figure 10 - A chart showing the temperature profile in a conventional embodiment.

Figures 11(a) - (e) are schematic process diagrams of a conventional mounting method.

Figure 12 - A chart showing the temperature profile of a conventional embodiment.

[Explanation of Symbols]

21 ... wiring board  
2a, 2b, 2c - 2n, 22a, 22b, 22c - 22n ... electrodes  
3a, 3b ... bumps  
4, 24 ... bare chip IC's  
5, 25 ... insulating resin  
6a, 6b, 6c - 6n, 26a, 26b, 26c - 26n ... meltable  
electrically conductive particles  
7, 27 ... anisotropic electrically conductive material